Sample registration of vital events with verbal autopsy: a renewed commitment to measuring and monitoring vital statistics

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Abstract Registration of births, recording deaths by age, sex and cause, and calculating mortality levels and differentials are fundamental to evidence-based health policy, monitoring and evaluation. Yet few of the countries with the greatest need for these data have functioning systems to produce them despite legislation providing for the establishment and maintenance of vital registration. Sample vital registration (SVR), when applied in conjunction with validated verbal autopsy procedures and implemented in a nationally representative sample of population clusters represents an affordable, cost-effective, and sustainable short- and medium-term solution to this problem. SVR complements other information sources by producing age-, sex-, and cause-specific mortality data that are more complete and continuous than those currently available. The tools and methods employed in an SVR system, however, are imperfect and require rigorous validation and continuous quality assurance; sampling strategies for SVR are also still evolving. Nonetheless, interest in establishing SVR is rapidly growing in Africa and Asia. Better systems for reporting and recording data on vital events will be sustainable only if developed hand-in-hand with existing health information strategies at the national and district levels; governance structures; and agendas for social research and development monitoring. If the global community wishes to have mortality measurements 5 or 10 years hence, the foundation stones of SVR must be laid today.

Keywords Vital statistics; Sample size; Mortality; Cause of death; Autopsy; Interviews; Data collection/methods; Information systems (*source: MeSH, NLM*).

Mots clés Statistique démographique; Taille échantillon; Mortalité; Cause décès; Autopsie; Entretien; Collecte données/méthodes; Système information (*source: MeSH, INSERM*).

Palabras clave Estadísticas vitales; Tamaño de la muestra; Mortalidad; Causa de muerte; Autopsia; Entrevistas; Recolección de datos/métodos; Sistemas de información (*fuente: DeCS, BIREME*).

Arabic

Making people count

Registration of births, recording deaths by age, sex and cause, and calculating mortality levels and differentials are fundamental to evidence-based health policy, monitoring and evaluation. Yet few of the countries with the greatest need for these data have functioning systems to generate them despite legislation providing for the establishment and maintenance of vital registration systems. Reliable data on age-, sex- and cause-specific mortality are lacking in more than half of all countries (*1*). Sample vital registration (SVR) systems are a viable solution to this predicament. SVR complements other sources of data, and should be considered a necessary part of comprehensive national health and demographic information systems.

Briefly, SVR is a community-based system implemented in a nationally representative cluster sample (Fig. 1). The three basic functions of SVR are: continuous enumeration of births, deaths and migrations; active follow-up of all perinatal deaths (i.e. stillbirths and infant deaths within 1 week of birth) to determine probable cause of death; and periodic independent re-enumeration of populations and vital events (births and deaths) to verify resident populations and assess completeness of registration (*2*). While these ideas are not new (*3*), there has

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been little adoption and promotion of SVR to date. Although the main outputs of interest from SVR are data on mortality, fertility and other demographic characteristics, optional nested or "rider" surveys using biomarkers or validated measures of poverty status (4, 5), for example, can be implemented in SVR systems and can complement statistics obtained from other sources.

Techniques used in SVR, including the verbal autopsy (VA) methods used to determine probable cause of death, are imperfect. (A VA is a questionnaire administered to the caregivers or family members of deceased persons to elicit signs and symptoms and their durations, and other pertinent information about the decedent in the period before death.) Nevertheless, the demand for and use of VA data by a variety of sources is rapidly gaining importance in the quest for evidence needed to set global health priorities (6–9).

SVR can be seen as leading towards universal vital registration or can serve as a permanent, stand-alone system. Indeed, SVR is already the best source of representative mortality statistics in China and India, and partial coverage has been obtained through a "sentinel" vital registration system in the United Republic of Tanzania (1, 6). National statistics offices and ministries of health in four African and two Asian countries are evaluating the costs and benefits of SVR and have begun to plan for and establish systems.

Status of vital registration and medical certification of deaths

The registration and documentation of vital events by civil authorities is a key public health function of a vital statistics system. This function, commonly termed "civil registration" or "vital registration" (VR), ideally serves a dual purpose: first, it meets legal requirements to establish civil status and protect individual rights; second, it should serve as a source of data for informing policy and planning. Unfortunately, relatively few VR systems produce data suitable for this purpose.

Births are generally not registered with sufficient completeness to provide accurate statistics; in sub-Saharan Africa registered births made up less than 1% of total estimated births in 2000 (10). There are also persistent disparities in death registration and in the quality of medical certification of causes. Of 115 Member States reporting mortality statistics to WHO, only 23 had high coverage, used the *International Statistical Classification of Diseases and Related Health Problems* (ICD) to assign causes, and reported a minimal proportion deaths as being due to ill-defined causes (1). In Africa, 42 of 46 Member States had no recent mortality data available, and more than half of these (n = 25) reported no mortality data at all (1).

Consequently, only about one third of the 56 million deaths estimated to occur annually are recorded by VR systems (1). Even where VR coverage is good, registration may be substantially less than 100%. Quality data on neonatal mortality (death during the first 28 complete days after birth), and among adults, are particularly scarce. VR systems register about 25% of neonatal deaths globally, of which only 1% of have causes ascribed (11). Correctly counting and distinguishing events such as late-term stillbirths from early neonatal deaths during the perinatal period is especially difficult in countries where a large proportion of births occur at home and are not detected by passive VR systems. Underscoring the need to improve the recording of mortality data around the time of birth is the fact

that nearly 40% of all deaths of children aged under 5 years occur in the neonatal period, and 75% of these are in the first week of life (12).

Several factors reduce the utility and comparability of cause-specific mortality data from VR even where coverage is good; particularly in low-income settings, good coverage does not equate with good cause attribution (13). The many deaths that occur at home (hence without medical certification) in resource-constrained countries are the chief obstacle to obtaining accurate data on counts and causes. In addition, religious, social, economic and even political inhibitions may hamper the reliable attribution of causes for deaths that occur at home (14, 15). Cause attribution for deaths that are medically certified is still problematic. For example, medical certifiers in countries heavily affected by human immunodeficiency virus (HIV) and acquired immunodeficiency syndrome (AIDS) can be pressured by family members not to mention AIDS on death certificates (16). More often, errors are unintentional. Even in Western Europe, where medical certification of death is virtually universal, implausibly high proportions of deaths may be attributed to causes thought to be particularly prevalent (1, 17). Differences between countries in the interpretation and application of ICD rules for determining the underlying cause further reduce comparability.

Assessing alternatives

Apart from vital registration, vital events are measured through: facility-based information systems; censuses; household surveys; research demographic surveillance sites (DSS); and epidemiological studies. All of these are necessary and complementary elements of a comprehensive national health information system. The outputs of all these sources, however, could be enhanced by mortality data from nationally representative SVR.

Routine facility-based information systems are essential for managing the public health system, and generally have wide coverage. However, they are often unreliable sources from which to derive population-level estimates of disease burden, primarily because the statistics they generate are biased towards those who actually use public health facilities, who tend to be better-off urban residents. Passive facility-based systems miss deaths that occur at home. In low-income, and even some medium-income countries, these may constitute the vast majority of all deaths in the population, and ascertainment is likely to be much worse in poorer communities (15, 18).

Censuses, which cover entire populations and can generate indirect estimates of mortality levels, are an important source of data for the measurement of mortality. Specific modules can estimate child, adult and age-specific mortality. There has been at least one attempt to track a specific cause of death (maternal mortality) in a national census (19). Unfortunately, census data have historically been of inadequate quality and collected with insufficient frequency to permit the analysis of child mortality, and the application of modules to measure adult mortality has not been a priority (16). Even if mortality measurement in censuses were improved, a national mortality assessment updated once per decade would be of limited use for most policy purposes or for planning, monitoring and evaluation.

Household surveys and some censuses have been the sole sources of data for measuring infant and child mortality in much of Asia and Latin America, and most of Africa (20). By 2000, few countries were without at least some information from

Fig. 1. **Basic sample vital registration (SVR) system functions and data flow**
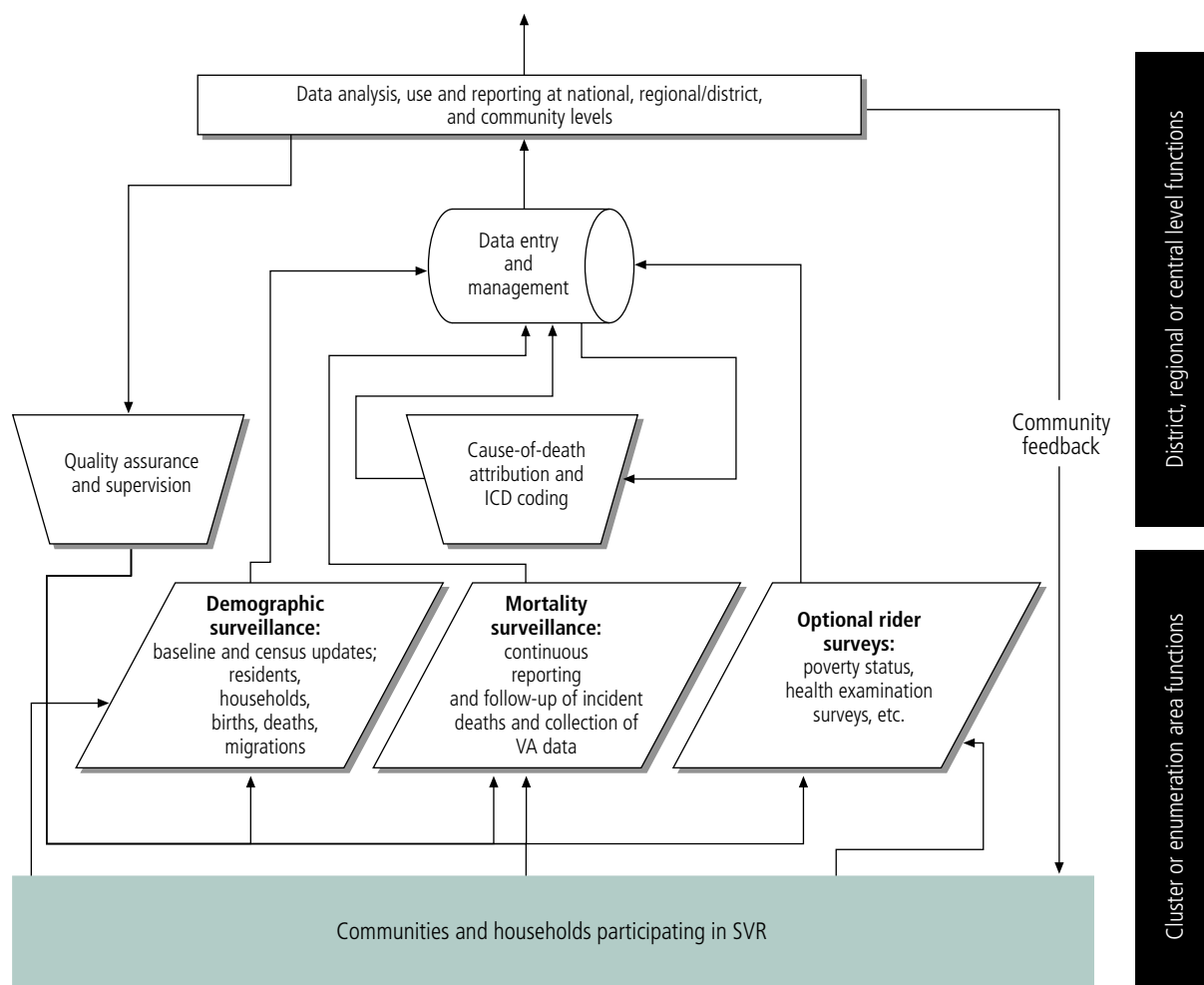
ICD, International Classification of Diseases; VA, verbal autopsy.

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these sources about mortality in children aged under 5 years, although data on causes remained scarce (*1*). Well-implemented nationally representative surveys produce high-quality data and are increasingly being designed to provide key indicators at the subnational level according to geography, ethnicity and poverty status. Current Demographic and Health Survey (DHS), samples are generally adequate to measure changes in total mortality of 15% or greater for children aged 0–4 years (*21*).

Although the contribution of and necessity for surveys is clear, they do have certain limitations with respect to mortality measurement. Because sample sizes for surveys have not necessarily been chosen specifically to detect mortality, they have generally been too small to allow disaggregation of data on infant mortality from that on child mortality at the national level, and subnational estimates of mortality trends in 0–4-year-olds are not stable (*21*). The under-reporting of deaths or misreporting of neonatal deaths as stillbirths, always a concern in the context of DSS, are of particular concern for cross-sectional surveys, which have only a single contact with households and generally require recall over a longer period than do DSS methods. In addition, as an artefact of both methods and sample sizes, mortality estimates are valid only for reference periods between 2.5 and 5 years prior to the year of the survey.

DHS-based estimates of adult mortality have also been produced, despite the more limited quantity and quality of data (*16*). On the whole, however, surveys have been less useful for measuring adult mortality, for which data, even on levels, remain extremely limited. Although indirect techniques for estimating adult mortality from partial and survey data exist (*16*, *22–24*), they are an imperfect substitute for direct measurement. Among adults, under-reporting in the sibling "survivorship" techniques (in which people are asked if they have or had any siblings, and if so, how many are currently alive) generally used in surveys has significantly affected estimates of maternal mortality ratios based on these methods (*25*). In fact, this particular indicator is so difficult to measure accurately through existing survey-based techniques that some have proposed abandoning it in favour of process and output indicators (*26*). SVR could provide a cost-effective means of overcoming this problem (*9*), as well as for the measurement of trends in more common causes of death such as malaria (*27*) and AIDS (*28*, *29*). Household surveys can play an important role in triangulating and complementing mortality measurement from SVR.

Research DSS and epidemiological studies generate both mortality data and methodological innovations for measuring them. Methods for attributing probable cause of death proposed

for use in SVR, for example, have been developed in research DSS sites. DSS sites are incubators for innovation in health development research and practice, and play a crucial role in developing and evaluating new interventions for diseases such as malaria (*30*). Pooled data from research DSS sites have been used to produce life tables for developing countries based on empirical data (*31*), and DSS and epidemiological studies have been an important source of data for estimating regional and global disease burdens and setting priorities (*8, 32–34*).

DSS is an indispensable source of international health development information (*31*). Yet certain characteristics make it problematic to rely indefinitely upon DSS data for national mortality statistics. DSS sites generally consist of one or two large surveillance areas comprised of several contiguous communities or neighbourhoods, and hence are not nationally representative. They are also frequently established in areas where diseases of public health importance are particularly prevalent, and serve as platforms for intensive research into interventions for those diseases (*31*); this also affects their representativeness. In addition, although pooling DSS data with those from epidemiological studies may yield important one-off estimates for setting high-level policy priorities (*7, 8, 34*), these cannot be systematically updated (because many epidemiological studies are not repeated) and so cannot be used to monitor progress.

SVR is prone to its own data quality concerns and design limitations (discussed below). The direct and continuous measurement of mortality and the use of samples specifically designed around mortality outcomes, however, will add considerable value to the statistics derived from the information sources mentioned above.

Issues in sample vital registration
Sampling and system costs
Designing a cost-efficient and nationally representative sample for SVR, and costing the establishment and continued operation of the system entails the consideration of several factors including (but not limited to): the total size of the system, number and size of clusters, and frequency of contact with households. Resolving these issues will be affected by factors such as the prevailing crude death rate, the proportion of deaths due to major causes in both sexes at different ages, and strategic decisions about stratification. There is currently little experience and no clear "best practice" in sampling and site selection for SVR; as yet only China and India have implemented nationally representative sampling for SVR. In India 6671 "sampling units" cover about 6 million people selected using the census as a sampling frame and simple random sampling of areas after stratifying rural and urban areas by "size classes". In China 145 "surveillance points" cover approximately 10 million people selected using multi-stage cluster sampling after stratifying for both urban and rural areas and socioeconomic status.

Recent analyses suggest that suitable samples for generating annual estimates from SVR could range from 450 000 to 2 million people, depending on a variety of factors, including those mentioned above (US Census Bureau and MEASURE Evaluation, unpublished data, and *35*), although significant adjustments to these estimates may be required to account for the design effect of cluster sampling, and uncertainty introduced by cause attribution. Alternative approaches to sampling may be appropriate in some situations, for example in countries with small total populations.

Sustainability is also a key concern in SVR. Within countries, SVR data systems will be sustainable only if they: are designed from the start around the demand for and use by national stakeholders of the data they generate; are developed with high-level political support; go hand-in-hand with national and district-level information strategies; are aligned with existing legal frameworks and governance structures; and gain the willing participation of populations included in the system. Over the long term a range of implementation models for SVR may emerge. SVR may exist in parallel with civil registration; be permanently integrated with it (e.g. to provide statistics from areas with poor health infrastructure to complement those from areas with adequate coverage); or be part of a longer range plan leading to universal routine VR with high-quality medical certification, strong legal backing and community acceptance. Ultimately, solutions will be found in the context of country needs and uses for the data SVR can produce and that are unlikely to come from any other source in the foreseeable future.

To date there has been virtually no documentation, comparison or generic estimation of the costs of health information systems in the peer-reviewed literature (see Rommelmann et al. in this issue of the *Bulletin* and *36*). It is difficult, therefore, to make generalizations about the costs of SVR, and even more difficult to relate these costs to those of other sources of information. The experience of some of the authors in implementing and costing the sentinel vital registration system in the United Republic of Tanzania, however, suggests that in addition to the total system size, operational costs are increased primarily by factors such as difficult topography, poor transport and communications infrastructure, and low population density of the clusters.

Verbal autopsy
Detailed descriptions of VA procedures are available from the authors or other sources, and much has been written about the use, validity, strengths and limitations of the method (*37–45*). The validity of these procedures is central to ensuring data quality in SVR. Briefly, after the VA interview has been conducted, a panel of physicians reviews the forms and assigns a probable cause of death. Medical records coders trained in ICD rules select and code the underlying cause of death according to the ICD "core code" or three-character level, and mortality results are tabulated using a standard condensed list capable of generating internationally comparable mortality statistics (*46*).

First, it must be stressed that the purpose of VA is to describe the cause structure of mortality at the community or population level where no better alternative sources exist; VA is not intended to diagnose the cause of death of individuals. It is, therefore, at best, a limited substitute for proper medical certification. The precision of VA depends upon factors that vary between and even within countries, and can also change over time. For example, the actual underlying cause structure of mortality affects patterns of misclassification of deaths, which reduces the accuracy of VA estimates (*40*). These cannot necessarily be adjusted for retrospectively (*47*).

In addition there are certain diseases, such as malaria in children, which have so far eluded effective measurement with VA. It is essential that such important diseases remain part of VA procedures and refinements. The estimates for these diseases can still be used for trend monitoring if they are affected by a consistent set of biases over time.

Even if it is unrealistic to expect VA to provide accurate measures of all major diseases in settings where its application is called for, the known shortcomings of this procedure should not prevent countries requiring information on cause-specific mortality from benefiting from it. Rather, rigorous VA validation studies should be carried out whenever it is applied in new epidemiological contexts. In this way, enough information about the operational characteristics of VA in a given population would be acquired to permit much improved estimates of population-level mortality.

Quality assurance

Rigorous and continuous quality assurance, stringent criteria and replicable validation studies will be of paramount importance if SVR is to attain its potential (see e.g. Rao et al. in this issue of the *Bulletin*). Such assessments will also help to determine best practice with regard to the optimal frequency of population re-enumeration in sample areas or clusters, and how to account for the effects of migration and population turnover. In addition VA validation studies should be conducted early on in the establishment of SVR, and periodically thereafter.

Some assessments of ascertainment and completeness for specific years for the systems in use in China (Rao et al., this issue), India (*48*) and the United Republic of Tanzania have been made (*49*) and have yielded estimates of the undercount (i.e. the number of events that the system misses) of vital events ranging from 7–14%. VA validation studies have recently been completed in China and the United Republic of Tanzania, and reports on the findings of these studies are being prepared for publication. (Cause-of-death attribution was only added to the Indian SRS in 2000 and has been pilot-tested over the past few years, using an evolving set of field procedures and data collection procedures.) More such work is needed as improved methods for the ascertainment of pregnancy outcomes and deaths are developed both within SVR systems, and adapted from sources such as surveys and demographic surveillance systems.

A renewed commitment

As the Director-General of WHO has argued, a genuine global commitment to improving measurements of the impact of health policies and programmes must re-emphasize a commitment to the measurement of vital events (*50*). Establishing a nationally representative SVR system in any country is resource-intensive and time-consuming. It is likely to take several years for a system to become fully operational and provide representative annual data. If the global community wishes to have access to mortality data on major health issues affecting populations 5 or 10 years hence, the foundation stones of SVR must be laid today. SVR offers the most feasible and cost-effective solution to what has been a serious and enduring deficit in the mortality evidence base for global health policy and planning. SVR should augment data from other sources and be considered an essential component of comprehensive national information systems in countries lacking the data that it can provide. Information from broad-based systems that include mortality measurement can be used to better guide and evaluate scaled up responses to current priorities, and prepare policy-makers for challenges to be confronted in the future. ∎

Résumé

Enregistrement par sondage des faits d'état civil ayant donné lieu à une autopsie verbale : nouvelle mobilisation en faveur du recensement et du suivi des statistiques d'état civil

Le recensement des naissances et des décès par âge, sexe et causes et le calcul des taux de mortalité et des écarts de mortalité sont indispensables à l'élaboration de politiques sanitaires reposant sur des bases factuelles, ainsi qu'à la surveillance et à l'évaluation de la santé. Cependant, peu de pays ayant fortement besoin de ces données disposent de systèmes opérationnels permettant de les générer, bien que les dispositions législatives prévoient la mise en place et la gestion d'un registre d'état civil. L'enregistrement par sondage des faits d'état civil (ES), lorsqu'il est pratiqué en association avec des procédures d'»autopsie verbale« validées et appliqué à un échantillon représentatif au plan national de groupes de population, représente une solution à ce problème abordable, d'un bon rapport coût/efficacité et durable à court et moyen terme. L'ES complète d'autres sources d'information en fournissant des données de mortalité par âge, sexe et causes plus complètes et continues que celles disponibles actuellement. Les outils et les méthodes utilisés dans le cadre d'un système ES sont cependant imparfaits. Ils doivent être validés selon une procédure rigoureuse et faire l'objet d'une démarche d'assurance de la qualité permanente. Les méthodes de sondage appliquées préalablement à l'ES sont également encore en évolution. Néanmoins, l'intérêt de la mise en place d'un ES grandit rapidement en Afrique et en Asie. On ne pourra faire fonctionner durablement des systèmes plus efficaces de collecte des données d'état civil que si ces systèmes sont développés en accord avec les stratégies d'information sanitaire au niveau du pays et du district, les structures administratives et les programmes de recherche dans le domaine social et de surveillance du développement qui existent déjà. Si la communauté mondiale souhaite disposer de mesures de la mortalité d'ici cinq à dix ans, les bases de l'ES doivent être mises en place dès aujourd'hui.

Resumen

Registro por muestreo de acontecimientos vitales mediante autopsias verbales: un compromiso renovado en la medición y vigilancia de las estadísticas vitales

El registro de los nacimientos, el registro de las defunciones por edad, sexo y causas y el cálculo de los niveles y diferenciales de mortalidad son fundamentales para articular políticas sanitarias basadas en la evidencia y para llevar a cabo el seguimiento y evaluación. No obstante, pocos de los países que más necesidad tienen de esos datos disponen de sistemas operativos para producirlos, aunque la legislación prevea el establecimiento y mantenimiento de sistemas de registro civil. Los sistemas de registro de estadísticas vitales por muestreo (REVM), si se combinan con procedimientos de autopsia verbal validados y aplicados en una muestra de conglomerados de población nacionalmente representativa, representan una solución asequible, costoeficaz y sostenible a corto y medio plazo para ese problema. Los REVM complementan otras fuentes de información generando datos de mortalidad por edad, sexo y causas que son más completos y continuos que los datos actualmente disponibles. Los instrumentos y métodos empleados en los sistemas REVM, sin embargo, son imperfectos y exigen mecanismos rigurosos de validación y una continua garantía de la calidad; también se están perfeccionando todavía las estrategias de muestreo para los REVM. Así y todo, el interés por establecer REVM está aumentando rápidamente en África y Asia. Unos sistemas mejorados de notificación y registro de los datos sobre acontecimientos vitales sólo serán sostenibles si se desarrollan en estrecha conexión con las estrategias de información sanitaria aplicadas en los niveles nacional y distrital, las estructuras de gobernanza, y las agendas de las investigaciones sociales y la vigilancia del desarrollo. Si la comunidad mundial desea disponer de mediciones de la mortalidad dentro de 5 o 10 años, hay que sentar ya las bases de los sistemas REVM.

Arabic

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